PhytoKeys 221: 117–129 (2023)
doi: 10.3897/phytokeys.221.97495
https://phytokeys.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
PhytoKeys
Launched to accelerate biodiversity research

# A new species of *Sedum* (Crassulaceae) from Mount Danxia in Guangdong, China

Yan-Shuang Huang[1*], Kai-Kai Meng[1*], Yuan-Yuan Sun[2], Zai-Xiong Chen[3], Qiang Fan[1]

**1** *State Key Laboratory of Biocontrol and Guangdong Provincial Key Laboratory of Plant Resources, School of Life Sciences, Sun Yat-sen University, Guangzhou 510275, China* **2** *School of Ecology, Sun Yat-sen University, Shenzhen 518107, China* **3** *Administrative Commission of Danxiashan National Park, Shaoguan 512300, China*

Corresponding author: Qiang Fan (fanqiang@mail.sysu.edu.cn)

Academic editor: J. Thiede | Received 12 November 2022 | Accepted 25 February 2023 | Published 10 March 2023

**Citation:** Huang Y-S, Meng K-K, Sun Y-Y, Chen Z-X, Fan Q (2023) A new species of *Sedum* (Crassulaceae) from Mount Danxia in Guangdong, China. PhytoKeys 221: 117–129. https://doi.org/10.3897/phytokeys.221.97495

## Abstract

*Sedum jinglanii*, a new species of Crassulaceae from Mount Danxia in Guangdong, China, is described and illustrated. Phylogenetic analysis based on the internal transcribed spacer (ITS) region of *nr*DNA suggests that the new species belongs to *S.* sect. *Sedum* sensu Fu and Ohba (2001) in the "Flora of China", and is sister to a clade comprising *S. alfredi* and *S. emarginatum* with high support values (SH-aLRT = 84, UFBS = 95) but is distantly related to *S. baileyi*. The new species is morphologically similar to *S. alfredi* but it can be distinguished from the latter in its opposite leaves (vs. alternate leaves), its usually wider leaves (0.4–1.2 cm vs. 0.2–0.6 cm), its usually shorter petals (3.4–4.5 mm vs. 4–6 mm), its shorter nectar scales (0.4–0.5 mm vs. 0.5–1 mm), its shorter carpels (1.5–2.6 mm vs. 4–5 mm), and its shorter styles (0.6–0.9 mm vs. 1–2 mm). The new species can be easily distinguished from *S. emarginatum* which both have opposite leaves by its short, erect or ascending rhizome (vs. long and prostrate rhizome in the latter), shorter petals (3.4–4.5 mm vs. 6–8 mm) and shorter carpels (1.5–2.6 mm vs. 4–5 mm). It can also be easily distinguished from *S. baileyi* by its short, erect or ascending rhizome (vs. long and prostrate rhizome) and its shorter style (0.6–0.9 mm vs. 1–1.5 mm).

## Keywords

Danxia landscape, morphology, nrITS, *Sedum* sect. *Sedum*

* These authors contributed equally to this work.

Copyright *Yan-Shuang Huang et al.* This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

## Introduction

According to Fu and Ohba (2001) in the "Flora of China", *Sedum* Linnaeus is the most species-rich genus of the family Crassulaceae, comprising about 470 species. However, as presently circumscribed, the genus is highly polyphyletic, and a monophyletic circumscribed genus *Sedum* s.l. would comprise approximately 755 species by inclusion of all 14 genera currently recognized in tribe Sedeae into it (Messerschmid et al. 2020). The genus is distributed in temperate and subtropical environments, and the diversity center is in the Mediterranean Sea, Central America, the Himalayas and East Asia (Stephenson 1994; Thiede and Eggli 2007). In China, 121 *Sedum* species are documented, amongst which 91 species are endemic (Fu and Ohba 2001).

During the past 20 years, about seventeen *Sedum* species have been newly described from China, including *S. hoi* X.F.Jin & B.Y.Ding (Wang et al. 2005), *S. plumbizincicola* X.H.Guo & S.B.Zhou (Wu et al. 2012), *S. fanjingshanense* C.D.Yang & X.Yu Wang (Yang et al. 2012), *S. kuntsunianum* X.F.Jin, S.H.Jin & B.Y.Ding (Jin et al. 2013), *S. tarokoense* H.W.Lin & J.C.Wang (Lu et al. 2013), *S. spiralifolium* D.Q.Wang, D.M.Xie & L.Q.Huang (Xie et al. 2014), *S. peltatum* M.L.Chen & X.H.Cao (Chen et al. 2017), *S. kwanwuense* H.W.Lin, J.C.Wang & C.T.Lu and *S. taiwanalpinum* H.W.Lin, J.C.Wang & C.T.Lu (Lu et al. 2019), *S. ichangense* Y.B.Wang (Wang and Xiong 2019), *S. lipingense* R.B.Zhang, D.Tan & R.X.Wei (Zhang et al. 2019), *S. nanlingense* Yan Liu & C.Y.Zou (Zou et al. 2020), *S. cirenianum* S.S.Ying, *S. shaoakouense* S.S.Ying and *S. shengkuangense* S.S.Ying (Ying 2022a), and *S. parviflorum* S.S.Ying and *S. tachingshuianum* S.S.Ying (Ying 2022b).

Molecular data unambiguously demonstrate the polyphyletic nature of *Sedum* with its species placed in four major crown clades of the crassulacean tree, for example, *Acre*, *Aeonium*, *Leucosedum*, and *Sempervivum*. There is no agreement between specialists regarding the infrageneric structure of *Sedum* (reviewed in Nikulin et al. 2016). According to Fu and Ohba (2001), Chinese *Sedum* are divided into three sections, including *S.* sect. *Sedum*, *S.* sect. *Oreades* (Fröderström) K.T. Fu, and *S.* sect. *Filipes* (Fröderström) S.H. Fu. *S.* sect. *Sedum* is distinguishable from the two latter sections by the adaxially gibbous carpels and follicles, while *S.* sect. *Oreades* differs from *S.* sect. *Filipes* in the spurred leaf base and yellow petals (vs. spurless leaf base and white or reddish-purple petals) (Fu and Ohba 2001). During our investigations in Danxiashan National Park, Guangdong Province, China, an unknown *Sedum* species with opposite leaves was collected. After several years of field observations, comprehensive literature studies and molecular analysis, we confirmed that it was a new species and it is described and illustrated here.

## Materials and method

Field investigations and observations were conducted during the flowering and fruiting periods of the putative new species. We obtained morphological data of this putative

species by measurements based on 6–8 living samples. Mean values of these statistical data were calculated and then were compared with six other related species (Table 2). The specimens were collected in Danxiashan National Park, Renhua County, Guangdong Province, China. Voucher specimens were deposited in the herbarium of Sun Yat-sen University (**SYS**).

Two representative individuals from different populations were selected for further molecular experiments, one from Bazhai of Mount Danxia (*Y. S. Huang 21040301*) and another one from Yanyan of Mount Danxia (*Q. Fan et al. DNPC 2873*). Fresh leaves of the two individuals were collected and stored with silica gel in zip-lock plastic bags until use. Total DNA was extracted using the modified CTAB method (Doyle and Doyle 1987). The region of the partial internal transcribed spacer 1, 5.8S ribosomal RNA gene and partial internal transcribed spacer 2 was amplified using previously reported primers ITS1 and ITS4 (White et al. 1990). PCR amplifications were performed following Huang et al. (2021).

In order to explore the phylogenetic position of the putative new species in *Sedum*, ITS sequences of 56 accessions representing 46 *Sedum* taxa and three outgroup species (*Aeonium lancerottense*, *Aeonium viscatum*, and *Greenovia aizoon*) were downloaded from the Genbank public database at the National Center for Biotechnology Information (NCBI) (Table 1). The sequences were aligned using ClustalW 1.8 (Thompson et al. 1994) and then adjusted manually. Besides, to improve the credibility, we also aligned the sequences using MAFFT v.7.402 (Katoh and Standley 2013), and the alignments generated from the two methods were consistent. The best-fit nucleotide substitution model was determined by ModelFinder (Kalyaanamoorthy et al. 2017). Based on the maximum likelihood (ML) method, the phylogenetic tree was constructed using IQ-Tree v. 2.0.3 (Nguyen et al. 2015) by executing 5,000 replicates of SH approximate likelihood ratio test (SH-aLRT) and ultrafast bootstrap (UFBS) (Hoang et al. 2018). Finally, the tree file was visualized by the online tool of Interactive Tree Of Life (iTOL) v5 (Letunic and Bork 2021).

## Results and discussion

The alignment length of the ITS sequences was 624 bp, amongst which 340 were parsimony-informative. Within the new species, only one variable site was detected, but 40 variable sites were detected between the new species and *S. alfredi* and 40 variable sites were detected between the new species and *S. emarginatum*, indicating that pronounced genetic differentiation existed between the new species and *S. alfredi* as well as *S. emarginatum*. The best-fit nucleotide substitution model was estimated as SYM+I+G4 according to the Bayesian Information Criterion (BIC).

As the ML phylogenetic tree shows (Fig. 1), seven subclades were resolved with moderate to high support values. Accessions of the putative new species, *S. alfredi*, *S. emarginatum*, and *S. lungtsuanense* together formed subclade 7 with high support values (SH-aLRT = 92, UFBS = 98), all belonging to *S.* sect. *Sedum* sensu Fu and Ohba (2001).

**Table 1.** Taxa, voucher information, and GenBank accession numbers of the sequences used in this study.

| Taxon | Voucher | Accession numbers | References |
|---|---|---|---|
| *Sedum* Sect. *Oreades* | | | |
| *S. oreades* | *Rao 090803-03* | KF113733 | Zhang et al. 2014 |
| *S. trullipetalum* | *Miyamoto et al. 9420132* | AB088630 | Mayuzumi and Ohba 2004 |
| *S. bergeri* | *Ni et al.* | AY352897 | Ni et al. unpublished |
| *S. erici-magnusii* | *Ito 2077* | LC229235 | Ito et al. 2017a |
| *Sedum* Sect. *Sedum* | | | |
| *S. jinglanii* | *Huang 21040301* | OP288035 | This study |
| | *Fan et al. DNPC 2873* | OQ162326 | This study |
| *S. actinocarpum* | *Ito 1749* | LC229265 | Ito et al. 2017a |
| *S. alfredi* | *Kokubugata 17190* | AB930259 | Ito et al. 2014a |
| | *Kokubugata 17191* | AB930260 | Ito et al. 2014a |
| | *Kokubugata 17192* | AB930261 | Ito et al. 2014a |
| | *WUK415208* | FJ919953 | Wang and Shu unpublished |
| *S. baileyi* | *LBG0064555* | FJ919935 | Wang and Shu unpublished |
| *S. bulbiferum* | *Ito 416* | LC229234 | Ito et al. 2017a |
| | *130514hs41* | KM111166 | Xie et al. 2014 |
| | *130524qz09* | KM111165 | Xie et al. 2014 |
| *S. emarginatum* | *130512hs27* | KM111145 | Xie et al. 2014 |
| *S. erythrospermum* | *Tsutsumi 1504* | AB906473 | Ito et al. 2014b |
| *S. formosanum* | *Ito 1260* | LC229279 | Ito et al. 2017a |
| *S. hakonense* | *Mayuzumi C00005* | AB088625 | Mayuzumi and Ohba 2004 |
| *S. hangzhouense* | *Ito 2604* | LC260130 | Ito et al. 2017b |
| *S. japonicum* | *Kokubugata 16749* | AB906475 | Ito et al. 2014b |
| *S. senanense* | *Ito 2200* | LC229238 | Ito et al. 2017a |
| *S. oryzifolium* | *Ito 2285* | LC229239 | Ito et al. 2017a |
| *S. japonicum* var. *pumilum* | *Ito 2287* | LC229240 | Ito et al. 2017a |
| *S. japonicum* ssp. *uniflorum* | *Ito 447* | LC229241 | Ito et al. 2017a |
| *S. boninense* | *Ito 2371* | LC229242 | Ito et al. 2017a |
| *S. jiulungshanense* | *Ito 76* | LC229243 | Ito et al. 2017a |
| *S. kiangnanense* | *CMQ1030* | LC229244 | Ito et al. 2017a |
| *S. lineare* | *Mayuzumi C00120* | AB088623 | Mayuzumi and Ohba 2004 |
| *S. lungtsuanense* | *Ito 3563* | LC260131 | Ito et al. 2017b |
| *S. makinoi* | *Kokubugata 16730* | AB906476 | Ito et al. 2014b |
| *S. morrisonense* | *Ito 2765* | LC229290 | Ito et al. 2017a |
| *S. multicaule* | *Miyamoto et al. TI9596136* | AB088631 | Mayuzumi and Ohba 2004 |
| *S. nagasakianum* | *Ito 2064* | LC229249 | Ito et al. 2017a |
| *S. nokoense* | *Kokubugata 10426* | AB906478 | Ito et al. 2014b |
| *S. oligospermum* | *Ito 74* | LC229250 | Ito et al. 2017a |
| *S. yabeanum* | *Ito 396* | AB906490 | Ito et al. 2014b |
| *S. polytrichoides* var. *setouchiense* | *Ito 2298* | LC229253 | Ito et al. 2017a |
| *S. polytrichoides* | *CMQ1057* | LC229251 | Ito et al. 2017a |
| *S. rupifragum* | *Ito 2070* | LC229254 | Ito et al. 2017a |
| *S. sarmentosum* | *Ito 978* | LC229255 | Ito et al. 2017a |
| *S. satumense* | *Ito 2295* | LC229256 | Ito et al. 2017a |
| *S. subtile* | *Shimizu 1999* | AB088622 | Mayuzumi and Ohba 2004 |
| | *Ito 2259* | LC229257 | Ito et al. 2017a |
| *S. subtile* | *Ito 624* | AB930277 | Ito et al. 2014a |
| *S. taiwanianum* | *Ito 2770* | LC229297 | Ito et al. 2017a |
| *S. tetractinum* | *Ito 3623* | LC260135 | Ito et al. 2017b |
| *S. tianmushanense* | *Ito 355* | LC229261 | Ito et al. 2017a |
| *S. tosaense* | *Kokubugata 16726* | AB906483 | Ito et al. 2014b |
| *S. triactina* | *9596091* | AB088629 | Mayuzumi and Ohba 2004 |
| *S. tricarpum* | *Ito 2269* | LC229259 | Ito et al. 2017a |
| *S. lipingense** | *ZRB1479* | MN150061 | Zhang et al. 2019 |
| *S. mexicanum** | *Ito 647* | LC229247 | Ito et al. 2017a |
| *S. truncatistigmum** | *Ito 3254* | LC229306 | Ito et al. 2017a |

| Taxon | Voucher | Accession numbers | References |
|---|---|---|---|
| *S. zentaro-tashiroi** | *Ohba 1998* | AB088619 | Mayuzumi and Ohba 2004 |
| Outgroups | | | |
| *Aeonium lancerottense* | *Mort 1518* | AY082143 | Mort et al. 2002 |
| *Aeonium viscatum* | *Mort 1432* | AY082154 | Mort et al. 2002 |
| *Greenovia aizoon* | *Mort 1425* | AY082112 | Mort et al. 2002 |

*Not recorded in Fu and Ohba (2001).

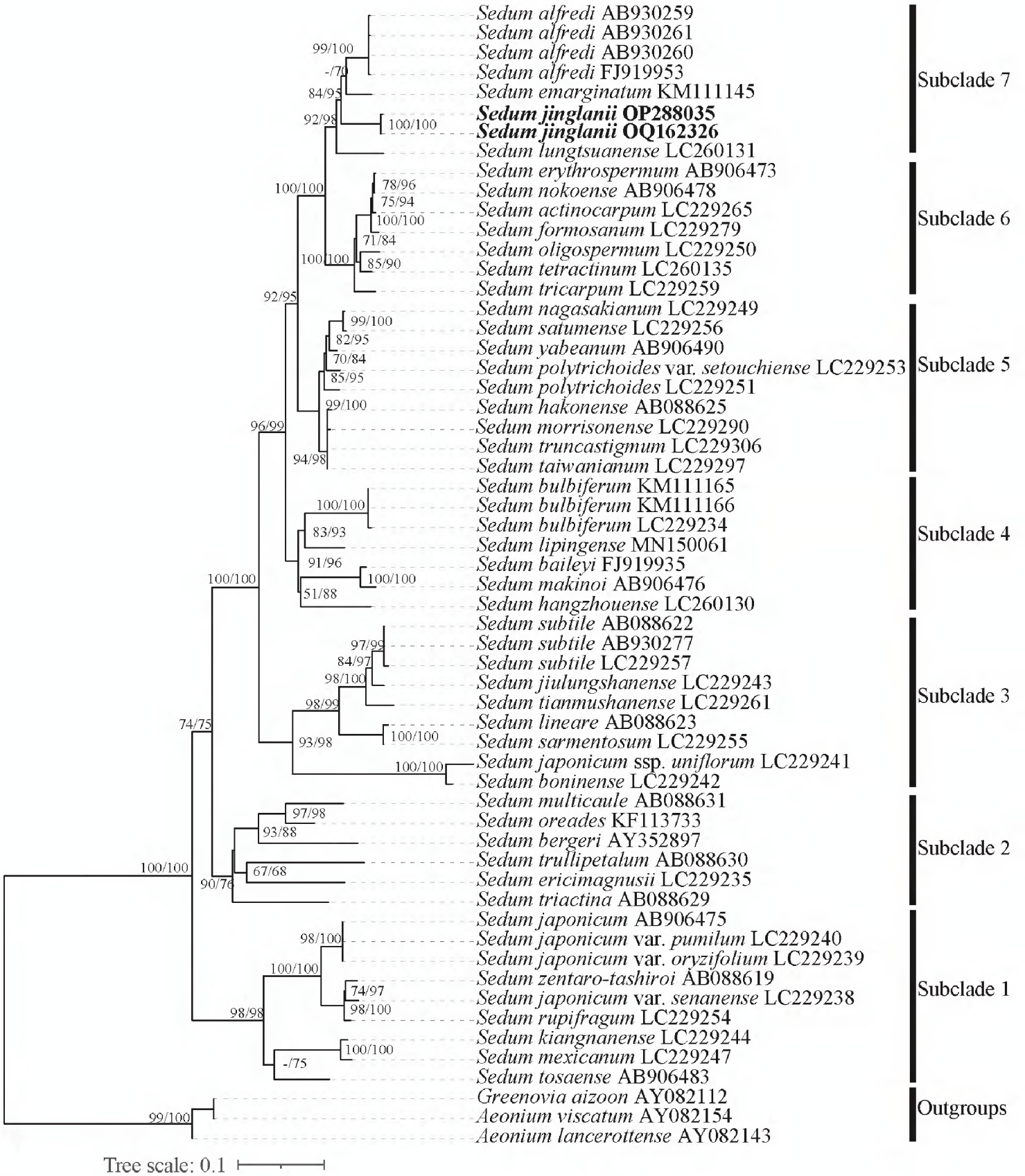


**Figure 1.** Maximum Likelihood tree based on ITS sequences for Eastern Asian species of *Sedum* sect. *Sedum*, four species of *S.* sect. *Oreades*, and three outgroups. Numbers near the branches are SH approximate likelihood ratio test (SH-aLRT) and ultrafast bootstrap (UFBS) support values. The new species is highlighted in bold.

Morphologically, the putative new species is similar to *S. alfredi* from which it can be easily distinguished by its opposite leaves (vs. alternate leaves in the latter). Furthermore, the leaves of the putative new species are usually wider than those of *S. alfredi* (0.4–1.2 mm vs. 0.2–0.6 mm), the petals are usually shorter (3.4–4.5 mm vs. 4–6 mm), the nectar scales shorter (0.4–0.5 mm vs. 0.5–1 mm), the carpels shorter (1.5–2.6 mm vs. 4–5 mm) and the styles shorter (0.6–0.9 mm vs. 1–2 mm) (Table 2). Phylogenetically, the putative new species is closely related to *S. emarginatum*. Although the leaves of both species are opposite, it can be easily distinguished from the latter by its short, erect or ascending rhizome (vs. long and prostrate rhizome), shorter petals (3.4–4.5 mm vs. 6–8 mm) and shorter carpels (1.5–2.6 mm vs. 4–5 mm). The putative new species was distantly related to *S. baileyi* in the phylogenetic tree although both are morphologically similar (Table 2). Also, it can be easily distinguished from the latter by its short, erect or ascending rhizome (vs. long and prostrate rhizome) and its shorter style (0.6–0.9 mm vs. 1–1.5 mm).

Additionally, four representatives of *Sedum* sect. *Oreades* sensu Fu and Ohba (2001) (*S. oreades*, *S. trullipetalum*, *S. bergeri*, and *S. erici-magnusii*) were also included in our analysis. However, these four species were nested within species belonging to *S.* sect. *Sedum* sensu Fu and Ohba (2001), thus showing that *S.* sect. *Sedum* might not be monophyletic. This result is consistent with previous studies (Nikulin et al. 2016; Zhang et al. 2019; Messerschmid et al. 2020).

Through numerous scientific investigations, more than a dozen new species were found on Mount Danxia in Guangdong in recent years, and most are endemic to it such as *Lespedeza danxiaensis* Q.Fan, W.Y.Zhao & K.W.Jiang (Zhao et al. 2021), *Asplenium danxiaense* K.W.Xu (Xu et al. 2022), *Pilea danxiaensis* L.F.Fu, A.K.Monro & Y.G.Wei (Fu et al. 2022), *Wikstroemia fragrans* W.B.Liao, Q.Fan & J.R.Chen (Chen et al. 2022), and *Commelina danxiaensis* Q.Fan, Long Y.Wang & W.Guo (Wang et al. 2023). As a World Heritage site and tourist attraction, Danxia landform possesses special and complicated habitat differences at a small scale, which might contribute to the plant endemism at Mount Danxia (Peng et al. 2018).

## Taxonomic treatment

***Sedum jinglanii* Yan S.Huang & Q.Fan, sp. nov.**
urn:lsid:ipni.org:names:77315511-1
景兰景天

**Type.** China. Guangdong Province, Renhua County, Mount Danxia, Bazhai, in the cliff of steep slopes, 25°00'N, 113°39'E, 520 m a.s.l., 3 April 2021, *Y. S. Huang 21040301* (holotype: SYS; isotype: SYS) (Figs 2, 3).

**Diagnosis.** This new species is similar to *S. alfredi*, but differs from the latter in its opposite leaves (vs. alternate leaves), its usually wider leaves (0.8–2.9 × 0.4–1.2 cm vs. 1.2–3.0 × 0.2–0.6 cm), usually shorter petals (3.4–4.5 mm vs. 4–6 mm), shorter nectar scales (0.4–0.5 mm vs. ca. 0.5–1 mm), and shorter carpels (1.5–2.6 mm vs.

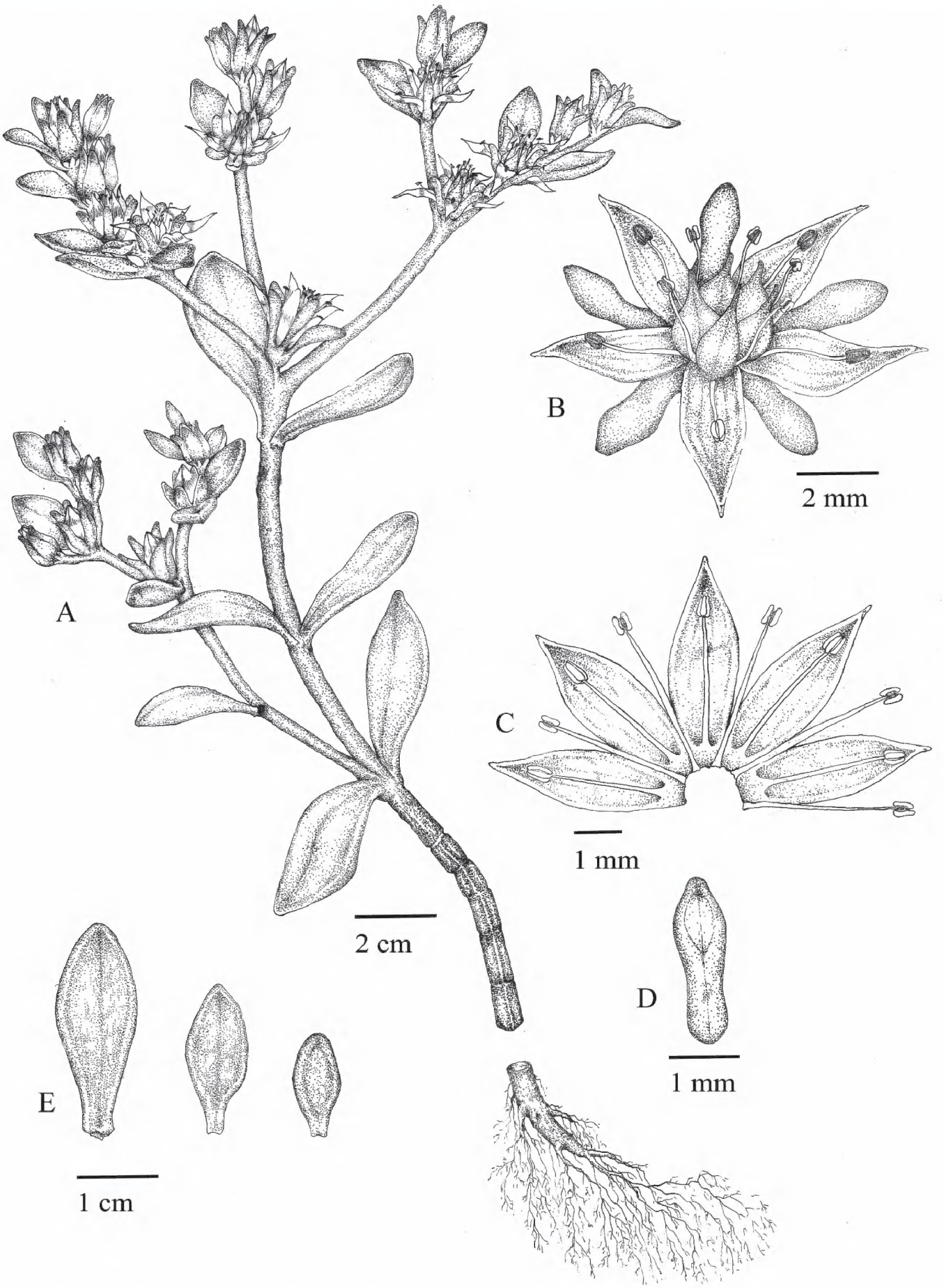


**Figure 2.** *Sedum jinglanii* sp. nov. **A** habit **B** flower with sepals, petals, stamens and carpels **C** petals and stamens **D** sepal **E** leaves. Illustration by Yuan-Yuan Sun based on living field-collected material (*Y. S. Huang 21040301*).

4–5 mm). Although the leaves of this new species and of *S. emarginatum* are opposite, it can be easily distinguished from the latter by its short, erect or ascending rhizomes (vs. long and prostrate rhizomes), shorter petals (3.4–4.5 mm vs. 6–8 mm) and shorter carpels (1.5–2.6 mm vs. 4–5 mm).

**Table 2.** Morphological comparisons between *S. jinglanii*, *S. alfredi*, *S. baileyi*, *S. emarginatum*, *S. kuntsunianum*, *S. makinoi*, and *S. satumense*.

| Characters | *S. jinglanii* | *S. alfredi*† | *S. baileyi*‡ | *S. emarginatum*§ | *S. kuntsunianum*\| | *S. makinoi*¶ | *S. satumense*# |
|---|---|---|---|---|---|---|---|
| Leaf blade | Spatulate or obovate | Linear-cuneate, spatulate or obovate | Obovate-spatulate | Spatulate-obovate to broadly obovate | Widely obovate or suborbiculate, spatulate | Obovate or obovate-spatulate | Narrowly obovate or spatulate |
| Leaf size (cm) | 0.8–2.9 × 0.4–1.2 | 1.2–3.0 × 0.2–0.6 | 1–2.5 × 0.6–0.8 | 1–2.5 × 0.5–1.2 | 1.4–2.0 × 0.9–1.5 | 1–2 × 0.6–0.8 | 1.0–2.2 × 0.6–0.9 |
| Phyllotaxy | Opposite | Alternate | Opposite | Opposite | Opposite, or rarely alternate at base | Opposite | Opposite |
| Rhizome | Short, erect or ascending | Short, erect or ascending | Long, prostrate | Long, prostrate | Absent | Short, erect or ascending | Short, erect or ascending |
| Sepal length (mm) | 2–3.1 | 2–5 | 1.5–2.5 | 2–5 | 5–9 | 2–3 | 6–7 |
| Petal length (mm) | 3.4–4.5 | 4–6 | 4–5 | 6–8 | 7–8 | 4–5 | 7–8 |
| Stamen length (antepetalous) (mm) | 2.2–2.6 | 2.5–3.5 | 2–3 | 3–4 | ca. 5 | 2.5–3.2 | – |
| Stamen length (antesepalous) (mm) | 3.2–3.3 | 3.8–4.5 | 3–4 | 4–5 | ca. 6 | 2.8–4.5 | – |
| Nectar scale length (mm) | 0.4–0.5 | 0.5–1 | 0.4–0.6 | 0.6–0.8 | ca. 0.5 | 0.5–0.7 | ca. 0.5 |
| Carpel length (mm) | 1.5–2.6 | 4–5 | 2–3 | 4–5 | ca. 5 | 4–5 | – |
| Style length (mm) | 0.6–0.9 | 1–2 | 1–1.5 | 1.5–2 | ca. 1 | 1–2 | 1.0–1.5 |

†,‡,§,¶ Based on Fu and Ohba (2001) and own measurements at IBSC and SYS; |Jin et al. (2013); # Ohba (2003).

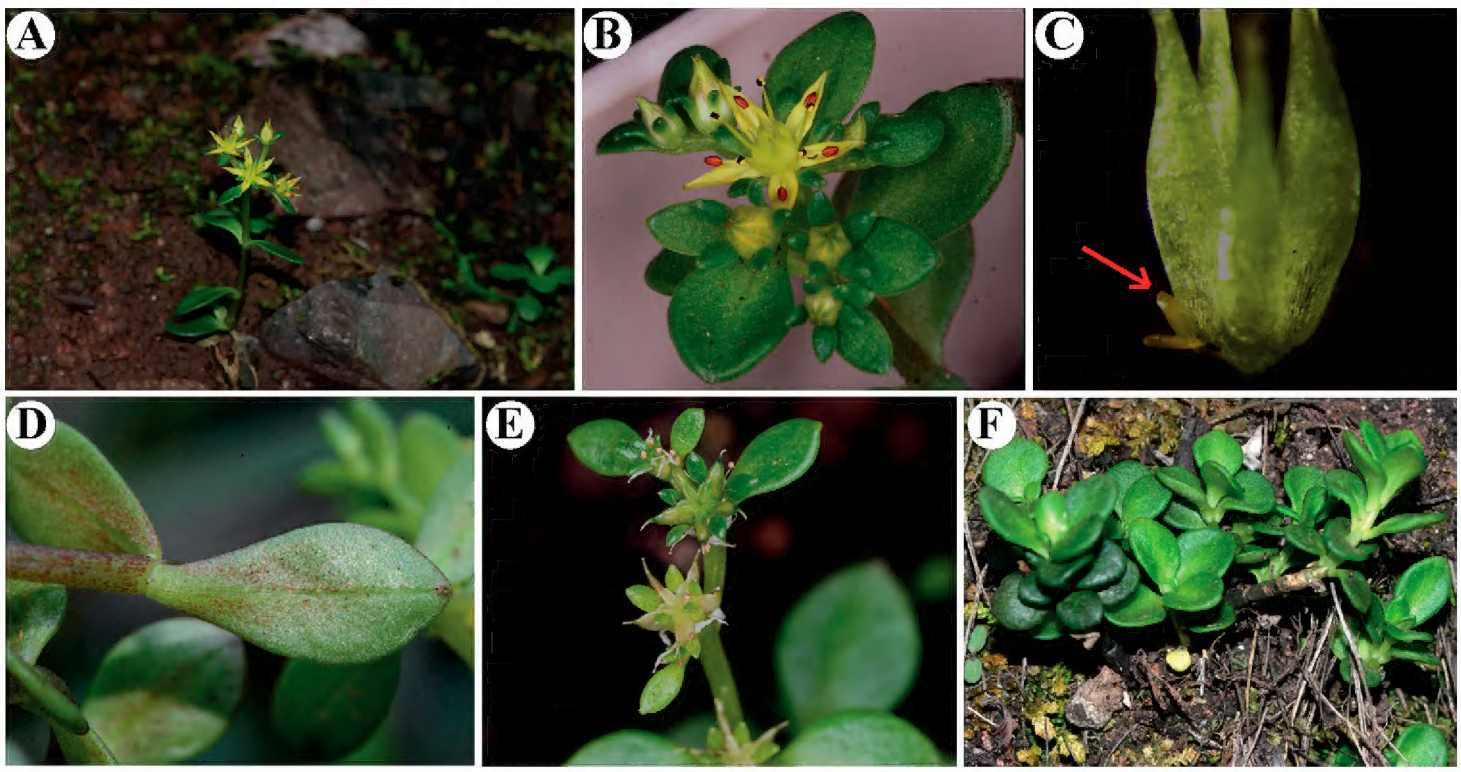


**Figure 3.** *Sedum jinglanii* sp. nov. **A** habit **B** flower, front view, showing brownish-red anthers **C** carpels and a nectar scale (red arrow) **D** abaxial leaf surface **E** young unripe fruits **F** young sterile individuals **A, B, D** photographed by Qiang Fan in the field (Pingtouzhai, 6 April 2022, *Q. Fan et al.*, *DNPC 1953*) **C** photographed by Min Lin in the lab (7 April 2022, *Q. Fan et al.*, *DNPC 1953*) **E, F** photographed by Yan-Shuang Huang (Bazhai, 3 April 2021, *Y. S. Huang 21040301*).

**Description.** Fleshy herbs, perennial; stems glabrous, greenish, often with small reddish dots thus appearing more or less reddish, ascending; leaves opposite, usually deciduous, crowded distally on the stem, succulent; leaf blade spatulate or obovate, 8–29 mm long, 4–12 mm wide, base narrowly cuneate and spurred, apex obtuse and sometimes emarginate; inflorescence in dense terminal cymes, usually two to four branched; bracts leaflike, 1.7–2.4 mm long, 0.7–1.1 mm wide; flowers usually sessile, rarely with short pedicels to 0.8 mm long, unequally 5-merous; sepals green, linear-spatulate, 2–3.1 mm × 0.7–1.4 mm, base shortly spurred; petals yellow, lanceolate to lanceolate-oblong, 3.4–4.5 mm × 0.8–1.1 mm, base connate for 0.1–0.2 mm, apex mucronate; stamens 10, yellow, filiform, arranged in 2 whorls; antesepalous ones 3.2–3.3 mm, antepetalous ones 2.2–2.6 mm; anthers brownish red, long ellipsoid. Nectar scales yellow green, spatulate-quadrangular, 0.4–0.5 × 0.2–0.3 mm, apex obtusely truncate. Carpels yellow green, erect, ovoid-lanceolate, 1.5–2.6 mm long, 0.6–0.9 mm wide, adaxially gibbous, base shortly connate; styles 0.6–0.9 mm long. Follicles yellowish, obliquely divergent. Seeds numerous, brown, oblong, 0.5–0.6 mm, papillate.

**Phenology.** Flowering from April to May. Fruiting from June to August.

**Etymology.** *Sedum jinglanii* is named after Prof. Jing-Lan Feng (1898–1976), an academician of the Chinese Academy of Sciences and one of the founders of mineralogy in China. In 1928, he discovered and named the red beds and related strata in North Guangdong as "Danxia Formation" for the first time (Peng 2020).

**Distribution and habitat.** Presently, this new species is only known from the type locality, Mount Danxia, Renhua County, Guangdong Province, China. It grows on the cliff of steep slopes at altitudes of 200–550 m a.s.l.

**Conservation status.** Only five populations were found with no more than 1,000 mature individuals. Thus, the conservation status could be considered as Vulnerable (VU; D1), according to the IUCN Red List Criteria (IUCN Standards and Petitions Subcommittee 2022).

**Additional specimens examined (paratypes).** China. Guangdong: Renhua County, Mount Danxia, Pingtouzhai, 25°00'N, 113°37'E, 536 m a.s.l., 6 April 2022, *Q. Fan et al.*, *DNPC 1953* (SYS); Renhua County, Mount Danxia, Yanyan, 25°02'N, 113°61'E, 263 m a.s.l., 27 December 2022, *Q. Fan et al. DNPC 2873* (SYS).

## Acknowledgements

We appreciate Mrs. Jing-Min Dai for her assistance in preparing the manuscript. We thank Prof. Yan-Song Peng from Lushan Botanical Garden, Chinese Academy of Sciences for his help in collecting living material of *Sedum baileyi* at the type locality. We thank Dr. Bin Chen, senior engineer at Shanghai Chenshan Botanical Garden, Chinese Academy of Sciences for his suggestions in nomenclature. We thank Mrs. Min Lin and Mrs. Li-Juan Liao for their help in the morphological analysis. We also kindly thank Zu-Hao Wang and Wen-Sheng Shu for unpublished sequence data, Yuan-Yuan Sun for the illustration, and the reviewers for their valuable comments. This study was supported by the Guangdong Provincial Special Research Grant for the Creation of National Parks (2021GJGY034) and the Foundation of Administrative Committee of Danxiashan National Park (K22-33000-060, 2016-0293).

## References

Chen ML, Han X, Zhang LF, Cao XH (2017) *Sedum peltatum* (Crassulaceae): A new species from Anhui, China. Bangladesh Journal of Botany 46(3): 847–852.

Chen JR, Lee SY, Guo JQ, Jin JH, Fan Q, Liao WB (2022) *Wikstroemia fragrans* (Thymelaeaceae, Daphneae), a new species from Mount Danxia, China based on morphological and molecular evidence. PhytoKeys 213(111): 67–78. https://doi.org/10.3897/phytokeys.213.91116

Doyle JJ, Doyle JL (1987) A rapid DNA isolation procedure for small quantities of fresh leaf tissue. Phytochemical Bulletin 19: 11–15.

Fu KT, Ohba H (2001) Crassulaceae. In: Wu ZY, Raven PH (Eds) Flora of China (Vol. 8). Science Press, Beijing, China and Missouri Botanical Garden Press, St. Louis, 202–268.

Fu LF, Xiong C, Monro AK, Fan Q, Chen ZX, Wen F, Xin ZB, Wei YG, Liao WB (2022) *Pilea danxiaensis* (Urticaceae), a new species in the Danxia landform from Guangdong, China including a description of the entire chloroplast genome. PhytoKeys 204(1): 109–119. https://doi.org/10.3897/phytokeys.204.86857

Hoang DT, Chernomor O, von Haeseler A, Minh BQ, Vinh LS (2018) UFBoot2: Improving the Ultrafast Bootstrap Approximation. Molecular Biology and Evolution 35(2): 518–522. https://doi.org/10.1093/molbev/msx281

Huang YS, Kang N, Zhong XJ, Liao WB, Fan Q (2021) A new species of *Viola* (Violaceae) from Guangdong Province, China. PhytoKeys 176: 67–76. https://doi.org/10.3897/phytokeys.176.65443

Ito T, Chen R, Yang QE, Saito Y, Yokota M, Kokubugata G (2014a) Taxonomic reexamination of *Sedum formosanum* (Crassulaceae) in Japan, Taiwan, and the Philippines based on molecular data. The journal of phytogeography and taxonomy 62(1): 1–9.

Ito T, Nakamura K, Park C, Song G, Maeda A, Watanabe Y, Kokubugata G (2014b) Nuclear and plastid DNA data confirm that *Sedum tosaense* (Crassulaceae) has a disjunct distribution between Pacific mainland Japan and Jeju Island, Korea. Phytotaxa 177(4): 221–230. https://doi.org/10.11646/phytotaxa.177.4.3

Ito T, Yu CC, Nakamura K, Chung KF, Yang QE, Fu CX, Qi ZC, Kokubugata G (2017a) Unique parallel radiations of high-mountainous species of the genus *Sedum* (Crassulaceae) on the continental island of Taiwan. Molecular Phylogenetics and Evolution 113: 9–22. https://doi.org/10.1016/j.ympev.2017.03.028

Ito T, Nakanishi H, Chichibu Y, Minoda K, Kokubugata G (2017b) *Sedum danjoense* (Crassulaceae), a new species of succulent plants from the Danjo Islands in Japan. Phytotaxa 309(1): 23–34. https://doi.org/10.11646/phytotaxa.309.1.2

IUCN Standards and Petitions Subcommittee (2022) Guidelines for Using the IUCN Red List Categories and Criteria. Version 15. Prepared by the Standards and Petitions Subcommittee. https://www.iucnredlist.org/resources/redlistguidelines

Jin SH, Zhou YY, Ding BY, Wang RW, Jin XF (2013) *Sedum kuntsunianum* (Crassulaceae: Sedoideae), a new species from southern Zhejiang, China. Phytotaxa 105(2): 33–38. https://doi.org/10.11646/phytotaxa.105.2.1

Kalyaanamoorthy S, Minh BQ, Wong TKF, von Haeseler A, Jermiin LS (2017) ModelFinder: Fast model selection for accurate phylogenetic estimates. Nature Methods 14(6): 587–589. https://doi.org/10.1038/nmeth.4285

Katoh K, Standley DM (2013) MAFFT multiple sequence alignment software version 7: Improvements in performance and usability. Molecular Biology and Evolution 30(4): 772–780. https://doi.org/10.1093/molbev/mst010

Letunic I, Bork P (2021) Interactive Tree Of Life (iTOL) v5: An online tool for phylogenetic tree display and annotation. Nucleic Acids Research 49(W1): W293–W296. https://doi.org/10.1093/nar/gkab301

Lu CT, Lin HW, Liou WT, Wang JC (2013) *Sedum tarokoense* (Crassulaceae), a new species from a limestone area in Taiwan. Botanical Studies (Taipei, Taiwan) 54(1): 1–57. https://doi.org/10.1186/1999-3110-54-57

Lu CT, Lin HW, Wang JC (2019) Two new species of *Sedum* (Crassulaceae) from Taiwan. Taiwania 64(4): 426–431. https://doi.org/10.6165/tai.2019.64.426

Mayuzumi S, Ohba H (2004) The Phylogenetic Position of Eastern Asian Sedoideae (Crassulaceae) Inferred from Chloroplast and Nuclear DNA Sequences. Systematic Botany 29(3): 587–598. https://doi.org/10.1600/0363644041744329

Messerschmid TF, Klein JT, Kadereit G, Kadereit JW (2020) Linnaeus's folly-phylogeny, evolution and classification of *Sedum* (Crassulaceae) and Crassulaceae subfamily Sempervivoideae. Taxon 69(5): 892–926. https://doi.org/10.1002/tax.12316

Mort ME, Soltis DE, Soltis PS, Francisco-Ortega J, Santos-Guerra A (2002) Phylogenetics and Evolution of the Macaronesian Clade of Crassulaceae Inferred from Nuclear and Chloroplast Sequence Data. Systematic Botany 27(2): 271–288.

Nguyen LT, Schmidt HA, von Haeseler A, Minh BQ (2015) IQ-TREE: A fast and effective stochastic algorithm for estimating maximum likelihood phylogenies. Molecular Biology and Evolution 32(1): 268–274. https://doi.org/10.1093/molbev/msu300

Nikulin V, Gontcharova S, Stephenson R, Gontcharov AA (2016) Phylogenetic relationships between *Sedum* L. and related genera (Crassulaceae) based on ITS rDNA sequence comparisons. Flora (Jena) 224: 218–229. https://doi.org/10.1016/j.flora.2016.08.003

Ohba H (2003) Crassulaceae. In: Iwatsuki K, Boufford DE, Ohba H (Eds) Flora of Japan (Vol. IIb). Kodansha Ltd., Tokyo, 10–31.

Peng H (2020) China Danxia. Higher Education Press, Beijing, 391 pp. https://doi.org/10.1007/978-981-13-5959-0

Peng H, Liu P, Zhang GH (2018) Small scale vegetation differentiation structure in Danxia Landforms, Southeast China. Dili Kexue 38(6): 944–953.

Stephenson R (1994) *Sedum*: Cultivated Stonecrops. Timber Press, Portland, 355 pp.

Thiede J, Eggli U (2007) Crassulaceae. In: Kubitzki K (Ed.) Flowering Plants Eudicots. The Families and Genera of Vascular Plants (Vol. 9). Springer, Berlin/Heidelberg, 83–118. https://doi.org/10.1007/978-3-540-32219-1_12

Thompson JD, Higgins DG, Gibson TJ (1994) CLUSTAL W: Improving the sensitivity of progressive multiple sequence alignment through sequence weighting, position specific gap penalties and weight matrix choice. Nucleic Acids Research 22(22): 4673–4680. https://doi.org/10.1093/nar/22.22.4673

Wang YB, Xiong XJ (2019) *Sedum ichangensis*, a new species of Crassulaceae from Hubei, China. PhytoKeys 132: 91–98. https://doi.org/10.3897/phytokeys.132.35428

Wang H, Song XJ, Liu QW (2005) *Sedum hoi*, a new species of the Crassulaceae from Zhejiang, China. Yunnan Zhi Wu Yan Jiu 27(3): 381–382.

Wang LY, Zhao WY, Chen ZX, Huang WC, Ding MY, Luo JC, Guo W, Fan Q (2023) *Commelina danxiaensis* (Commelinaceae), a new species from Guangdong, China. PhytoKeys 218(6): 117–126. https://doi.org/10.3897/phytokeys.218.91199

White TJ, Bruns T, Lee S, Taylor J (1990) Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. PCR protocols: A Guide to Methods and Applications 18(1): 315–322. https://doi.org/10.1016/B978-0-12-372180-8.50042-1

Wu LH, Liu YJ, Zhou SB, Guo FG, Bi D, Guo XH, Baker AJM, Smith JAC, Luo YM (2012) *Sedum plumbizincicola* X.H. Guo et S.B. Zhou ex L.H. Wu (Crassulaceae): A new species from Zhejiang Province, China. Plant Systematics and Evolution 299(3): 487–498. https://doi.org/10.1007/s00606-012-0738-x

Xie DM, Peng DY, Fang CW, Qin MJ, Wang DQ, Huang LQ (2014) *Sedum spiralifolium* (Crassulaceae): A new species from Anhui Province, China. Phytotaxa 183(3): 171–182. https://doi.org/10.11646/phytotaxa.183.3.4

Xu KW, Lin CX, Guo JQ, Zhou XX, Liao WB, Mao LF (2022) *Asplenium danxiaense* sp. nov. (Aspleniaceae, Aspleniineae), a new tetraploid fern species from Guangdong, China, based on morphological and molecular data. European Journal of Taxonomy 798(1): 162–173. https://doi.org/10.5852/ejt.2022.798.1679

Yang CD, Wang XY, Gou GQ (2012) *Sedum fanjingshanensis* C. D. Yang et X. Y. Wang, a new species of *Sedum* L. Bulletin of Botanical Research 32(4): 389–391.

Ying SS (2022a) Four New species of genus *Sedum* (Crassulaceae) from Taiwan. New Taxa and New Names 4: 87–112.

Ying SS (2022b) Two New species of genus *Sedum* (Crassulaceae) from Taiwan. New Taxa and New Names 5: 39–49.

Zhang JQ, Meng SY, Wen J, Rao GY (2014) Phylogenetic Relationships and Character Evolution of *Rhodiola* (Crassulaceae) based on Nuclear Ribosomal ITS and Plastid *trnL-F* and *psbA-trnH* Sequences. Systematic Botany 39(2): 441–451. https://doi.org/10.1600/036364414X680753

Zhang RB, Deng T, Dou QL, He L, Lv XY, Jiang H (2019) *Sedum lipingense* (Crassulaceae) identifying a new stonecrop species in SE Guizhou, China, based on morphological and molecular evidence. PhytoKeys 134(3): 125–133. https://doi.org/10.3897/phytokeys.134.38287

Zhao WY, Jiang KW, Chen ZX, Tian B, Fan Q (2021) *Lespedeza danxiaensis* (Fabaceae), a new species from Guangdong, China, based on molecular and morphological data. PhytoKeys 185(1): 43–53. https://doi.org/10.3897/phytokeys.185.72788

Zou CY, Meng SY, Lu ZC, Liu Y (2020) *Sedum nanlingense* (Crassulaceae), a new species from Guangxi, China. Phytotaxa 447(3): 176–184. https://doi.org/10.11646/phytotaxa.447.3.3